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FIRST SPECTRUM OF TANTALUM

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ABSTRACT

Wave lengths of more than 2,100 lines emitted by the arc in air between electrodes of tantalum metal have been measured in the spectral region from 10,300 A in the infrared to 2,300 A in the ultraviolet. These lines are characteristic of the spectrum emitted by neutral tantalum atoms. Many of the lines are clearly complex and present the appearance of narrow rectangles. Several lines in the ultraviolet, which have been found to originate in the lowest energy state, were observed as absorption lines in the spectrum of the underwater spark. The arc spectrum is always accompanied by an extensive band spectrum, attributable to the oxide, which consists of bands shaded toward the red from inconspicuous heads. Whenever recognized as such, these heads have been measured.

CONTENTS

I. INTRODUCTION

The properties of a chemical element, which must be known in order to understand its physical and chemical behavior, now include a tabulation of its atomic energy states as revealed by analyses of the term structures of its spectra. But analysis of the term structure of a spectrum, especially if it is complex, requires an accurate and extensive list of wave lengths together with such descriptive features of the individual lines as intensity, Zeeman effect, reversibility, hyperfine structure, and others.

For the element tantalum, atomic number 73, which has been known to chemists for more than a century, only 13 papers descriptive of its spectra were listed by Kayser in volume 6 of the Handbuch der Spectroscopie. In the interval that has elapsed since the publication of this work in 1912, numerous papers on the tantalum spectra have appeared, but most of these deal with the X-ray spectra and only a few with the optical spectra. In 1917, Frl. Josewski [1] published new wave-length measurements in the range from 2,427 A in the ultraviolet to 7,007 A in the red. Although her work did not extend our knowledge of tantalum spectra beyond the limits reached in the earlier investigations, nevertheless it furnished an accurate scale of wave lengths from which corrections for the earlier measurements could be derived. In 1927, Allin and Ireton [2] published a list of ultraviolet tantalum lines which they observed as absorption lines in the spec-

[1] Zeit. wiss. Phot., vol. 17, p. 79; 1917.
[2] Trans. Roy. Soc., Canada, sec. 3, vol. 21, p. 127, 1927.

trum of the underwater spark; and in 1928 McLennan and Durnford [3] published some measurements of the Zeeman effect for tantalum lines lying between 5,519 and 6,675 A. Quite recently, brief notes have appeared by: (1) Kiess and Kiess, [4] who give a preliminary list of terms for the spectrum of neutral tantalum atoms; (2) Gisolf and Zeeman [5] who report measurements of the hyperfine structure of certain lines of tantalum and a value of 7/2 for its nuclear moment; (3) McMillan and Grace, [6] who likewise have measured hyperfine structures and have found a nuclear moment of 7/2.

Investigation of the tantalum spectra was begun at the Bureau of Standards more than 10 years ago when it was realized that the first requisite for a successful analysis of the term structure of a complex spectrum is an extensive and accurate list of its wave lengths. It was planned, therefore, to photograph the spectra emitted by tantalum arcs and sparks throughout the domain accessible to us with the spectrographs and photographic materials at our disposal, and to supplement this survey with observations of the Zeeman effect and of the underwater spark. The observational work involved in this program is practically completed but much still remains to be done in the way of measurement and calculation. In this paper, we present a list of the lines we have measured in the spectrum emitted by neutral tantalum atoms, together with estimates of their intensities and descriptions of certain characteristics we have noted for them. In subsequent papers it is planned to present the results obtained from work now in progress for the spectra emitted by ionized atoms, for the Zeeman effect, and for the term structures of the spectra.

II. EXPERIMENTAL PROCEDURE

The spectrograms on which this investigation is based were secured with the grating and prism spectrographs of the Bureau of Standards. The gratings and their mountings have been described in previous papers.[7] The prism spectrograph, constructed by Hilger, is new, and is believed to be the most powerful instrument of its kind in existence. It is provided with two quartz prisms—one a 60° Cornu prism, and the other a 30° reflecting prism—with faces measuring 12 by 20 cm. The instrument is mounted in the Littrow style, the lens being 12 cm in diameter. Between 2,100 and 3,000 A the dispersion of this spectrograph varies from 0.4 to 2 A per mm.

The prism spectrograph was used in photographing the ultraviolet portions of the tantalum spectra between 2,100 and 3,100 A. The various grating spectrographs were used from 2,200 A to the limit reached at 10,300 A in the infrared. For the regions from 2,200 to 2,900 A and from 5,000 to 9,000 A the first order of the 20,000 lines-per-inch grating, giving a dispersion of 3.6 A per mm, was used. The second order of this grating was used for the plates covering the interval from 2,900 to 5,000 A. For the infrared regions of the spectrum the Anderson grating, giving a dispersion of 10 A per mm, was used.

In making a spectrogram, the light from the arc and from the spark discharge between electrodes of the same metal, was photographed in juxtaposition on two strips of the plate. Adjacent to these were

[3] Proc. Roy. Soc., London, vol. A 120, p. 502, 1928.
[4] B.S., Jour. Research, vol. 11 (RP589), p. 277, 1933.
[5] Nature, vol. 132, p. 566, 1933.
[6] Phys. Rev., vol. 44, p. 325, 1933; and vol. 44, p. 949, 1933.
[7] B. S. Scientific Papers nos. 312, 441, and 499.

exposures to the iron arc to furnish the standard scale used in the wave-length determinations. The spark exposures were faint, however, and revealed no lines other than the strongest arc lines in the regions longer than 3,700 A. Consequently, no attempt was made in this investigation to photograph the spark spectrum to waves longer than 5,000 A. To photograph the regions not readily recorded with ordinary plates, special plates were used. These comprised: (1) Schumann plates, prepared according to the recommendations of Hopfield and Appleyard; [8] (2) plates sensitized to the green, yellow, red, and near infrared by bathing them in suitable dye solutions according to our usual practice; [9] and (3) the new infrared plates brought out by the Eastman Kodak Co.[10]

The material used as electrodes in the arcs and sparks was metallic tantalum kindly sent to us for this investigation by C. W. Balke [11] of the Fansteel Co., who has described its preparation. The arcs were maintained by direct currents of 5 to 10 amperes supplied by 220-volt mains. The sparks were maintained by a battery of condensers of 0.006 μf capacity which were charged by transformers of either 10,000 or 40,000 volts, stepped-up from the 110 volt ac circuit. The tantalum arc in air has a tendency to flicker, and, after molten beads of the oxide have formed on the electrodes, the ends of the arc travel along the electrodes away from oxide beads which soon solidify. The oxide when cool is nonconducting and it is necessary to bring the electrodes into contact repeatedly in order to maintain the arc. Furthermore, a dense cloud of hot oxide particles surrounds and pervades the arc so that the line spectrum in regions longer than 2,400 A is always superposed on a continuous spectrum.

III. RESULTS

Our measurements of the tantalum spectra have yielded a list of 2,100 lines which, we believe, are emitted by neutral atoms. All lines recognized as emitted by ionized atoms have been omitted from the list which is presented in table 1. Except for a few lines each recorded wave length is the mean of 2 to 6 accordant measurements made, for the most part, by 2 observers. The reference lines, chosen from the iron spectrum, were the adopted international secondary standards in the regions where these are available. In the ultraviolet where no secondary standards have yet been adopted Burns' [12] values of the iron lines, determined by interference methods, have been used. The arc in air emits an extensive band spectrum attributable to the oxide of tantalum. These bands are shaded toward the red from heads which are not very prominent. Whenever recognized as such these heads have been measured and their wave lengths are included in table 1, where they are designated by a letter *n*.

Early in the work of measurement, it was noticed that many of the tantalum lines are not sharp and fine but present the appearance of narrow rectangles. Some of these wide lines exhibit nearly uniform intensity distribution from one edge to the other which is indicated in the table by the letter *b*. Others show partial resolution into hyperfine structure, which is indicated by the letters *c* and *d*. Lines

[8] Jour. Opt. Soc. Amer., vol. 22, p. 488, 1932.
[9] B. S. Scientific Papers, no. 422, vol. 17, p. 353, 1921.
[10] Jour. Opt. Soc. Amer., vol. 23, p. 229, 1933.
[11] Chem. Met. Eng., vol. 27, p. 1271, 1922. Ind. Eng. Chem., vol. 15, p. 560, 1923; and vol. 21, p. 1002, 1929.
[12] Compt. rend., vol. 160, p. 243, 1915; Publ. Allegheny Obs., vol. 6, p. 180, 1929; and vol. 8, p. 43, 1931.

marked with *c* are made up of several components, and many of them exhibit flag-shaped patterns; lines designated with *d* present the appearance of close doublets. The letters *l* and *v* indicate, respectively, that the lines are shaded toward longer or shorter wave lengths. In all cases of complex lines, the recorded wave length is a mean value and refers either to the geometrical center of the rectangular line or to the maximum of intensity, indicated on the spectrograms by the protrusion of an astigmatic tail into the iron comparison spectrum. The letter *r* indicates lines that are absorbed in the under-water spark. Most of the lines so designated are intense and lie in the ultraviolet. They have been found to be related to the basic term, ^4F, of the spectrum. It is to be noted that none of them agree with the under-water spark lines recorded by Allin and Ireton for tantalum.

Although the tantalum metal used for electrodes was the purest that had ever been prepared in quantity, yet it was found to contain several impurities of which the most prominent was its analogue columbium. The other impurities, present only in very minute quantity, were tungsten, iron, nickel, silicon, and tin. In the "Revision of Rowland's Preliminary Table of Solar Spectrum Wave-Lengths", St. John[13] lists tantalum among the elements not at that time identified in the sun. It is of interest to note that its presence in the sun is now revealed by the agreement of several of its strongest lines with hitherto unidentified faint solar lines. Among these are the three at 5,997, 5,944, and 5,939 A, which have their origin in the metastable ^6D term of Ta I.

TABLE 1.—*Wave lengths in the first spectrum of tantalum,* Ta I

λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes
10,325.70	2	9,569.57	15	8,936.51	4	8,088.94	2	7,758.23	2
10,303.71	1	9,523.75	3	8,932.63	8	8,076.49	1	7,757.61	2
10,210.90	3	9,512.70	3	8,924.91	2	8,069.05	4	7,733.70	2
10,198.70	1	9,487.20	2	8,834.75	4	8,058.96	1	7,725.09	4
10,195.97	2	9,453.52	3	8,819.58	2	8,053.96	2	7,722.03	10
10,187.99	2	9,438.55	4	8,757.65	1	8,039.11	7	7,719.19	3
10,099.41	15	9,423.80	4	8,721.88	2	8,029.04	2	7,715.03	3
10,079.45	3	9,423.12	2	8,709.00	1*b*	8,026.49	12	7,699.14	5
10,043.27	5*n*	9,288.15	3*b*	8,704.02	1	8,022.09	2	7,690.35	3
9,989.75	5*n*	9,272.63	10	8,652.99	1*b*	7,998.75	2	7,676.24	3
9,971.26	4*n*	9,259.69	4	8,645.60	1*b*	7,996.74	1	7,670.28	7*c*
9,957.94	4*n*	9,254.95	2	8,595.86	7	7,955.54	2*b*	7,650.42	3
9,954.68	4*n*	9,246.16	6	8,583.37	1	7,952.19	2	7,649.62	8
9,941.50	10	9,242.70	5*n*	8,575.92	8	7,950.24	15	7,640.84	4
9,919.90	8*n*	9,231.20	3	8,560.42	1	7,926.58	1	7,625.97	3
9,902.74	5*n*	9,197.40	8*n*?	8,551.91	1	7,921.65	1*n*?	7,622.64	3*b*
9,868.62	25*n*	9,196.05	4*n*	8,550.51	5	7,887.39	1	7,620.84	3
9,849.37	15*n*	9,126.22	1	8,447.62	10	7,882.37	25	7,604.81	2*b*
9,840.33	3	9,123.07	3	8,415.73	3	7,856.48	1	7,593.62	3
9,827.36	3	9,105.70	5	8,413.85	1	7,842.76	15	7,591.38	2*d*?
9,818.67	4	9,088.85	1	8,391.08	1	7,819.57	2	7,590.22	7
9,784.54	8	9,082.30	1	8,389.17	2	7,818.82	2*b*	7,569.18	5
9,780.93	4	9,038.60	1*b*	8,382.25	1	7,815.47	10	7,553.97	4
9,680.75	2	9,032.05	3*b*	8,281.65	20	7,814.00	18	7,541.96	2
9,645.53	20	9,021.60	1	8,264.90	6	7,799.51	4	7,520.56	15
9,640.92	3*d*?	9,008.78	1	8,248.99	4	7,788.95	3	7,515.18	7*b*
9,634.27	4	8,984.70	3	8,180.81	1	7,788.64	2	7,495.31	5
9,608.74	3	8,977.19	1	8,158.53	2	7,779.68	12*b*	7,492.74	3
9,596.75	2	8,975.41	1	8,128.77	3	7,773.52	2	7,490.06	2*b*
9,590.83	1	8,946.15	1	8,100.11	2	7,763.10	10	7,486.55	2

[13] Carnegie Inst. of Washington, Pub. no. 396, p. XX; 1928.

TABLE 1.—*Wave lengths in the first spectrum of tantalum,* Ta I—Continued

λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes
7,486.01	12	7,025.02	20	6,691.45	1	6,360.84	15	6,133.89	2
7,482.36	2	7,013.92	3	6,684.00	10	6,356.16	18*b*	6,131.21	4
7,471.99	7*c*	7,006.95	25	6,675.53	25	6,351.22	4	6,129.64	2
7,469.05	4	7,005.92	4	6,673.72	20	6,345.99	10	6,126.79	2
7,467.71	12	7,005.05	15	6,669.01	4	6,341.17	12	6,122.92	1
7,460.80	4*d*?	7,003.09	2	6,662.29	8*c*, *l*	6,340.01	3*b*	6,106.51	3
7,454.38	3*b*	7,000.20	8	6,639.41	3	6,332.89	10	6,101.56	12
7,440.14	10	6,995.35	20*d*?	6,632.17	2	6,327.41	2	6,099.96	2
7,435.16	6	6,983.52	7	6,626.15	4*b*	6,326.62	5	6,093.56	2
7,418.86	4	6,981.99	3*d*?	6,621.29	20	6,325.09	15	6,092.95	2
7,410.60	2	6,977.66	3	6,611.91	25	6,321.51	2*b*	6,092.07	5
7,407.87	25	6,971.50	15*c*	6,605.86	3	6,312.22	9	6,091.44	3*b*
7,404.93	2	6,969.49	7	6,587.16	6*b*	6,309.59	18	6,090.81	7
7,389.03	2	6,966.14	25	6,585.09	6	6,309.07	10	6,087.92	1
7,371.03	2	6,957.67	2	6,580.51	1	6,289.33	12	6,087.11	3*b*
7,369.12	20	6,953.86	10	6,578.96	3*d*,?	6,287.91	10	6,084.71	4
7,356.94	18	6,951.23	15	6,577.57	4*b*	6,287.36	8	6,071.75	1
7,355.41	4	6,950.05	4	6,577.12	5	6,283.02	5	6,070.57	4
7,352.87	25	6,946.88	10	6,574.84	18	6,281.36	12*b*	6,059.34	5*c*
7,346.37	30	6,939.33	5	6,570.27	1	6,280.53	2	6,053.70	8
7,343.32	2	6,936.05	2	6,568.23	1	6,278.34	12	6,047.25	18
7,340.14	6*c*	6,928.53	25	6,564.27	10*c*	6,277.55	2*b*	6,045.38	30
7,333.04	2*d*?	6,927.37	20	6,563.72	2	6,274.30	3	6,038.27	2
7,325.94	7	6,919.38	1	6,561.60	10	6,272.52	2*b*	6,034.96	2
7,322.71	10*b*	6,910.47	1	6,559.71	2	6,271.35	1	6,023.37	3
7,319.82	10	6,902.07	20	6,559.26	4	6,268.70	25	6,020.72	18*c*
7,313.18	3	6,900.54	12	6,556.88	2	6,266.38	7	6,019.07	2
7,301.74	25	6,896.76	9	6,547.24	4	6,262.31	2	6,015.90	8
7,296.30	12	6,892.53	3*b*	6,530.70	1	6,258.72	5*b*	6,012.55	5
7,293.80	1	6,888.34	2	6,527.04	4	6,256.68	20	6,009.92	10
7,286.35	7	6,877.46	10	6,516.14	20	6,254.66	8*c*, *v*	6,007.43	2
7,284.43	2	6,875.24	25	6,514.40	20	6,254.16	2	5,999.24	3
7,277.54	6	6,867.33	2*b*	6,505.52	15	6,249.81	10	5,998.21	2
7,276.95	15	6,866.23	25	6,502.43	12	6,247.33	2	5,997.24	35*c*
7,272.25	5	6,865.10	5	6,500.40	2	6,244.47	7*c*	5,974.12	3
7,264.82	12	6,860.78	3	6,486.08	8	6,239.19	5	5,960.12	7
7,250.27	20	6,850.78	8	6,485.36	30	6,238.04	1	5,958.98	2
7,233.46	8	6,833.73	2	6,479.93	3	6,228.01	3	5,958.24	1
7,226.40	3	6,833.24	4	6,472.84	2	6,225.81	1	5,951.78	8
7,207.86	5*b*	6,831.97	6	6,459.91	10	6,223.62	4	5,944.01	30*d*?
7,196.23	3	6,824.94	5*b*	6,459.07	4	6,222.69	2	5,939.75	20*b*
7,191.34	9	6,819.33	7	6,457.38	3	6,221.33	2	5,935.53	5
7,177.42	3	6,813.24	25*c*	6,455.83	5	6,218.98	5	5,931.68	6
7,175.74	5	6,810.42	10	6,453.07	2	6,217.01	5	5,931.06	7
7,174.91	10*d*	6,799.27	7	6,450.37	25	6,212.45	2	5,930.59	5
7,172.91	25	6,797.67	2	6,445.87	12	6,208.37	8	5,925.91	5*b*
7,152.71	2	6,790.07	5	6,444.61	10	6,200.32	3	5,922.39	3*b*
7,148.61	30	6,788.98	18	6,443.88	7*b*	6,194.94	3	5,918.94	15
7,135.22	4	6,787.59	1	6,440.42	3*b*	6,194.39	2	5,916.51	9
7,125.72	20	6,776.68	1	6,437.33	6	6,193.11	7	5,912.79	4*b*
7,121.27	10	6,774.22	15*c*	6,434.54	3	6,189.67	7	5,907.68	2*b*
7,118.06	3	6,771.71	20	6,430.78	30	6,179.04	4	5,904.34	5
7,117.51	12*b*	6,770.33	4	6,428.62	15*b*	6,170.85	4	5,901.90	12
7,116.07	4*b*	6,755.82	5	6,426.72	4	6,170.47	6	5,897.93	4
7,108.06	5	6,754.88	10	6,425.44	3	6,167.38	2	5,895.19	5*b*
7,093.00	10	6,740.74	18	6,418.48	2	6,165.61	1	5,892.45	3
7,092.14	3*b*	6,726.88	1	6,417.99	2*v*	6,160.05	1	5,888.49	4
7,091.35	2	6,714.44	3	6,392.18	8	6,158.84	8	5,886.46	3
7,085.39	10	6,709.36	10	6,389.45	20	6,154.49	15	5,882.29	12
7,081.35	8*b*	6,706.42	6	6,387.98	3	6,152.52	8	5,881.40	3
7,074.64	4	6,705.94	4	6,379.07	7	6,147.06	4*b*	5,877.36	20
7,049.87	3*b*	6,702.96	4	6,373.06	10	6,144.60	10*c*, *l*	5,872.03	3
7,039.06	12	6,699.05	1	6,369.04	3	6,141.19	3	5,866.58	8
7,036.56	3	6,693.60	7	6,364.92	5	6,140.08	8	5,865.85	7
7,031.50	6	6,691.97	1	6,364.06	2	6,138.11	2	5,861.43	3

TABLE 1.—*Wave lengths in the first spectrum of tantalum,* Ta I—Continued

λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes
5,859.73	1	5,605.51	7*b*	5,342.24	12	5,069.90	7	4,758.05	5*c*
5,857.90	2	5,598.76	7	5,341.06	35*c*	5,067.86	25	4,756.50	10
5,857.05	2	5,592.66	2	5,336.12	15	5,064.58	3	4,754.10	4*b*
5,854.92	2	5,589.04	1*n*	5,328.38	20*c*	5,058.69	5*b*	4,745.92	5
5,853.86	3	5,584.02	15*c*	5,317.32	3	5,044.86	3	4,740.14	10*c*
5,849.81	12*c*	5,581.39	4	5,310.92	2	5,044.40	7	4,739.44	3
5,848.85	5*b*	5,577.21	3	5,295.00	20	5,043.32	25	4,738.34	4
5,847.95	2	5,566.99	4*n*	5,293.40	6	5,041.85	5	4,730.11	8
5,843.93	12	5,555.80	1*b*	5,287.07	3	5,039.85	2	4,722.88	8
5,842.85	3	5,549.32	3	5,281.05	10	5,037.65	30	4,706.10	8+Cb?
5,837.29	2	5,548.32	10*b*	5,279.80	12	5,037.33	30*c*	4,701.31	7
5,836.64	2	5,545.20	8*c*	5,275.01	12	5,017.06	7	4,693.35	7
5,835.86	3	5,536.76	5*b*	5,273.25	4	5,012.54	25	4,691.91	20*c*
5,828.17	3	5,530.37	5*b*	5,261.53	3*b*	4,998.15	3	4,688.84	4
5,825.11	4*b*	5,528.36	7*b*	5,260.41	4	4,993.27	3	4,685.27	5
5,824.35	2	5,523.99	6*b*	5,252.13	3*b*	4,977.82	4	4,684.88	8
5,820.74	2	5,521.15	5	5,247.72	3*b*	4,976.19	7	4,684.22	3
5,816.51	8	5,520.21	2*n*?	5,244.77	4*b*	4,969.73	15*c*	4,681.88	15
5,811.10	20*d*?	5,518.91	30*c*	5,235.39	12*c*	4,968.52	7	4,679.46	3*n*
5,799.47	4	5,517.69	4*b*	5,233.43	5	4,958.09	8	4,678.01	5
5,797.70	4*b*	5,516.24	5*b*	5,230.80	15	4,938.86	3*b*	4,669.15	12
5,793.76	4	5,513.52	6*b*	5,218.67	25	4,937.63	15	4,661.10	12*c*
5,792.50	4	5,505.67	10	5,218.44	20	4,936.41	30	4,651.92	3*n*
5,783.27	5	5,503.05	2	5,215.35	2	4,933.50	6	4,640.77	6*b*
5,780.70	18	5,500.69	15	5,212.75	35*c*	4,931.57	3	4,633.05	8
5,780.01	10	5,494.81	18	5,206.55	2	4,926.02	35	4,622.96	5
5,779.31	4*b*	5,490.13	20	5,206.24	3	4,924.96	10	4,621.81	4
5,776.76	20	5,486.77	2	5,193.99	3*b*	4,923.47	15*c*	4,619.52	15
5,771.94	8	5,485.44	1*n*?	5,188.92	4	4,922.59	3*b*	4,604.86	4*c*?
5,767.90	15*c*	5,481.13	15+Cb?	5,180.93	7*c*	4,921.29	25	4,602.19	7*c*
5,766.55	12	5,475.57	25	5,173.11	7*b*	4,920.88	10	4,601.42	7
5,765.69	1	5,472.22	7	5,171.64	5*b*	4,920.13	35*c*	4,583.18	4*b*
5,761.59	8	5,471.54	10	5,166.79	12	4,918.85	3	4,580.70	7
5,755.80	12	5,461.31	25	5,163.64	15	4,917.20	5	4,576.60	4
5,755.04	2	5,458.43	10	5,161.82	18*c*	4,914.97	10	4,574.32	15
5,754.54	1	5,456.60	3	5,156.57	20	4,911.38	7	4,573.32	8
5,751.79	2	5,454.46	3	5,156.33	20	4,907.72	12	4,571.98	4
5,749.80	2	5,446.22	5	5,153.42	15	4,904.58	20	4,566.85	4
5,746.68	10	5,438.34	3	5,150.87	7	4,901.57	3*n*?	4,565.86	10
5,740.08	3	5,435.27	30	5,148.76	7	4,883.94	8	4,556.35	10*c*
5,735.16	2	5,433.00	8*b*	5,147.94	4	4,881.94	5	4,553.70	6*b*
5,733.51	4	5,431.65	10	5,145.18	2	4,881.51	2	4,551.96	12*c*
5,730.51	4*b*	5,419.19	30*c*	5,143.70	20	4,879.13	4	4,547.17	4
5,727.72	4*b*	5,418.01	6	5,141.83	4	4,871.68	5*b*	4,530.80	12
5,724.41	3	5,413.47	20*c*	5,141.63	30*c*	4,864.65	3	4,527.50	8
5,722.78	4*b*	5,410.55	10	5,139.03	2	4,864.34	2	4,521.71	2
5,716.53	8*b*	5,408.78	15	5,136.47	30*c*	4,862.50	3	4,521.09	10*b*
5,715.25	12	5,405.80	6*b*	5,135.89	4	4,861.04	3	4,511.48	7
5,706.30	15*c*	5,404.95	35*b*	5,133.88	2	4,852.67	3	4,510.97	40*d*,?
5,704.31	10	5,403.53	5	5,132.32	7	4,852.16	7	4,509.28	6
5,699.24	18	5,402.51	40*b*	5,132.10	12	4,846.80	4*d*?	4,496.50	6
5,697.95	1	5,397.54	15	5,130.52	4	4,846.43	8	4,494.98	3
5,688.25	15	5,395.96	20*c*	5,126.66	3*b*	4,843.79	3	4,480.92	7
5,685.50	2	5,389.30	25*c*	5,122.31	5	4,832.16	7	4,473.53	10
5,680.04	1	5,388.48	15	5,117.23	12	4,825.42	8	4,462.36	3
5,667.71	1	5,385.79	3	5,115.84	35	4,821.93	4	4,459.79	12
5,664.90	25+Cb?	5,385.25	3*n*?	5,109.78	12	4,819.52	9	4,450.73	10
5,659.28	2	5,383.88	3	5,109.37	12*c*	4,815.12	5	4,441.76	12*b*, +Cb?
5,654.86	2*b*	5,379.65	4	5,098.37	7	4,812.74	10		
5,651.59	2	5,373.00	8	5,091.64	4	4,810.35	4*n*	4,441.05	12
								4,432.97	7
5,645.92	20*d*?	5,365.92	8	5,090.71	25	4,789.27	2		
5,640.19	12	5,354.67	30*c*	5,087.37	20	4,786.65	6	4,431.09	4
5,635.71	10	5,349.58	25	5,082.26	15	4,780.94	8	4,430.96	5
5,620.69	15*c*	5,349.08	25*c*	5,076.38	18	4,768.99	10	4,430.40	12
5,617.73	5	5,348.09	2	5,072.45	3	4,758.90	3	4,424.97	3
								4,419.56	5

TABLE 1.—*Wave lengths in the first spectrum of tantalum,* Ta I—Continued

λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes
4,415.74	12	4,063.41	3	3,885.20	8	3,732.74	3	3,625.23	8
4,402.49	20*c*	4,062.80	4	3,879.43	5	3,731.02	10	3,624.10	4*b*
4,398.45	10	4,062.58	3	3,876.56	5	3,728.84	4	3,623.41	2
4,386.07	10	4,061.39	10*c*	3,875.21	4*b*	3,728.11	4	3,620.01	2
4,378.82	10	4,058.47	4	3,872.73	4	3,727.46	3	3,617.31	3
4,375.15	4	4,058.14	3*b*	3,870.64	4*b*	3,725.58	2	3,616.01	4
4,374.21	3	4,055.38	4*b*	3,866.70	3	3,725.03	2	3,612.82	2
4,372.80	4	4,054.40	4*b*	3,866.47	5	3,723.09	4	3,612.37	2
4,369.36	4	4,041.80	4	3,861.06	4	3,720.62	1	3,611.13	5
4,364.83	4	4,041.37	3	3,859.82	8	3,719.40	2	3,609.33	4
4,360.81	7*c*	4,041.05	8	3,858.59	7*b*	3,718.45	3	3,609.17	5
4,358.65	4	4,040.86	10	3,853.58	4	3,718.09	3	3,608.76	6
4,355.13	10*c*	4,039.62	4	3,851.43	3	3,714.89	3	3,607.41	15
4,351.01	4	4,035.90	7	3,849.74	4	3,714.35	2	3,604.97	4
4,344.32	6	4,033.07	8	3,849.44	6	3,711.15	3	3,600.70	4
4,336.20	2	4,031.95	3	3,848.05	10	3,710.79	4	3,598.81	3
4,329.59	5	4,030.67	4	3,846.62	5	3,709.66	2	3,598.06	3
4,322.70	4	4,029.94	10	3,844.04	5	3,706.59	2	3,596.86	4
4,318.82	5	4,026.94	12	3,842.88	7	3,706.31	2	3,595.64	7
4,314.54	5	4,015.23	5	3,842.34	5	3,706.08	3	3,592.49	4
4,302.97	15*c*	4,014.63	3*b*	3,839.42	4	3,705.17	3	3,592.14	3
4,286.40	6*c*	4,013.54	3	3,839.04	10	3,704.24	3	3,589.97	3
4,280.48	5	4,013.18	4	3,836.62	8	3,703.27	3	3,586.29	7
4,279.07	10	4,012.10	5	3,833.76	15	3,701.33	4	3,584.50	7
4,271.52	7*b*	4,007.22	4	3,832.28	4	3,700.27	3	3,584.21	7
4,268.27	10*c*	4,006.83	10	3,828.95	10	3,699.99	3	3,580.90	2
4,245.36	10	4,006.24	4*n*	3,826.85	10	3,695.39	5	3,580.04	2
4,244.00	5	4,003.70	6	3,826.18	6	3,693.05	6	3,579.08	5
4,228.63	10	3,999.27	15	3,823.60	12	3,689.74	5	3,578.77	2
4,224.62	4	3,996.16	20*c*	3,820.75	5	3,686.82	4	3,577.78	3
4,206.40	15	3,995.28	3	3,819.72	5	3,686.19	5	3,576.24	2
4,205.88	20*c*	3,990.39	4	3,812.85	4*b*	3,685.89	2	3,573.43	5*b*
4,201.97	4*b*	3,988.70	8	3,812.32	4*b*	3,684.97	3*b*	3,571.85	6
4,193.10	4	3,984.97	4*b*	3,809.70	4	3,684.31	3	3,571.15	4
4,191.27	4*b*	3,984.26	3	3,809.26	3	3,683.05	4	3,570.74	4*b*
4,191.18	7	3,983.82	4	3,807.74	3	3,681.26	4	3,570.32	4
4,181.15	10*c*	3,981.95	8	3,802.02	4*b*	3,681.05	3	3,569.19	3
4,177.91	7	3,981.01	4	3,801.79	4	3,676.88	3	3,567.35	4
4,177.00	4	3,979.27	6*c*	3,801.14	4	3,675.49	3	3,566.73	7
4,175.20	40*c*	3,970.10	15	3,800.00	4	3,675.13	4	3,566.01	3
4,161.00	5	3,968.16	4*b*	3,797.41	4	3,674.83	5	3,564.80	5
4,159.98	3	3,959.72	4	3,792.03	9	3,666.88	3	3,557.95	5*d?*
4,154.41	7*n?*	3,956.58	5	3,788.76	5	3,666.10	3	3,556.55	2
4,147.90	15	3,954.30	4*b*	3,785.26	4	3,665.35	3	3,555.71	4
4,136.21	15	3,952.16	5*b*	3,784.26	15*c*	3,663.83	3	3,553.43	5
4,129.37	30*c*	3,942.22	3	3,783.78	4	3,663.10	3	3,549.07	5
4,127.88	8	3,937.85	5	3,782.30	4	3,662.34	5	3,540.82	4
4,123.65	3	3,930.93	7	3,780.16	4	3,661.68	5	3,537.55	4
4,123.17	10*c*	3,930.23	4	3,779.10	4*b*	3,658.78	6*b*	3,536.30	5
4,118.06	3	3,925.26	4	3,777.11	7*b*	3,657.49	5	3,532.22	4
4,114.78	4	3,922.93	9	3,770.92	6	3,657.28	5	3,531.59	6
4,105.03	10	3,922.77	10	3,760.20	4	3,656.90	4	3,528.63	5
4,104.24	5	3,922.42	4*b*	3,759.76	5	3,656.34	2	3,527.08	5
4,097.19	4	3,918.52	10	3,757.74	4	3,656.05	3	3,517.45	3
4,092.10	3*n?*	3,912.43	4	3,755.09	6	3,655.94	3	3,514.39	3
4,091.65	3	3,912.13	4	3,754.52	5	3,655.65	2	3,513.62	5
4,091.26	7*b*	3,909.33	4	3,747.25	4*n*	3,653.81	4	3,512.82	3*b*
4,085.79	5	3,905.28	4*b*	3,746.38	8	3,653.40	5	3,511.04	10
4,081.78	3	3,898.76	4	3,743.67	3	3,652.42	4	3,507.33	2
4,079.19	8	3,898.15	4	3,742.67	3	3,648.00	4	3,506.90	3
4,077.72	5	3,896.43	4*n*	3,742.09	3	3,642.06	20	3,505.19	7
4,073.00	4	3,894.67	4	3,741.27	2	3,633.75	5	3,504.96	7
4,067.90	20*c*	3,893.03	3	3,738.25	3	3,627.01	5	3,503.87	8
4,067.23	15	3,890.70	3	3,737.96	2	3,626.61	10	3,502.88	5
4,064.63	15	3,890.50	3	3,736.77	10	3,625.68	4*n*	3,502.50	5

TABLE 1.—*Wave lengths in the first spectrum of tantalum,* Ta I—Continued

λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes
3,501.96	4*d*?	3,405.69	1	3,311.16	20*c*	3,239.98	5*c*	3,154.50	3
3,497.85	10	3,404.16	3	3,309.80	5	3,237.86	5	3,153.93	2
3,493.44	4*c*	3,401.83	3	3,308.89	1	3,236.40	4	3,153.08	4*b*
3,490.95	5	3,398.34	9	3,308.56	2	3,235.87	2	3,152.54	3
3,489.16	3	3,397.42	2	3,307.10	3	3,234.69	5	3,152.01	2
3,488.86	4	3,395.40	1	3,305.36	3	3,232.28	4	3,150.84	5
3,488.55	2	3,393.43	1	3,305.14	3	3,231.67	3	3,149.77	3
3,487.39	3	3,388.83	4	3,304.39	5	3,230.87	10*c*	3,148.04	5
3,486.69	4	3,387.46	4	3,304.05	4	3,229.87	5*c*	3,147.39	5*c*
3,484.63	5	3,387.23	2	3,302.78	4	3,229.23	10*c*	3,146.77	3
3,484.24	2	3,385.05	10	3,302.32	2*b*	3,227.32	6	3,141.01	2
3,480.51	10*d*?	3,383.84	3	3,301.91	4	3,226.86	5	3,138.50	4*b*
3,479.44	3	3,383.16	1	3,299.78	6	3,226.32	3	3,138.32	3
3,477.63	2	3,381.97	3	3,299.28	3	3,223.84	10	3,136.59	2
3,477.44	4	3,380.64	4	3,297.19	2*b*	3,221.32	7	3,136.30	2
3,477.23	3	3,379.95	3*b*	3,295.33	7*d*?	3,220.06	3*c*	3,135.88	5
3,473.90	5	3,379.51	5	3,294.74	2	3,219.60	6*c*	3,133.55	4
3,473.33	4	3,378.20	2	3,293.94	5	3,217.98	3*b*	3,132.65	7
3,472.84	4	3,377.78	3	3,292.50	5	3,216.92	7*d*?	3,131.24	2
3,472.53	5	3,376.49	4	3,291.91	4, Cb?	3,216.64	2	3,130.60	7*d*
3,466.86	3	3,376.05	5	3,291.39	3*b*	3,215.99	3	3,130.31	2
3,465.51	2	3,373.72	2	3,289.86	3	3,209.85	3	3,129.96	6
3,463.93	4	3,371.54	10	3,288.48	3	3,208.64	3	3,129.56	6
3,462.87	3	3,369.28	5	3,287.28	3	3,208.21	3	3,129.15	4
3,462.19	2	3,366.66	5	3,286.44	1	3,207.86	6	3,124.97	6
3,460.12	3	3,365.03	3	3,284.63	3	3,206.79	3	3,121.54	2
3,458.53	2	3,364.12	3	3,283.83	2	3,206.38	7	3,120.92	4
3,456.07	2	3,362.53	4	3,282.55	1*b*	3,205.48	5*b*	3,119.62	4
3,453.36	2	3,361.66	6	3,280.88	6	3,203.76	4*c*	3,117.45	6
3,452.98	4	3,358.99	4	3,280.27	2	3,201.97	4	3,115.87	5*d*?
3,450.42	3	3,358.47	10	3,279.28	6	3,198.67	8*c*	3,113.91	6*c*
3,448.92	4	3,357.32	2	3,278.33	2	3,196.37	4	3,110.11	4
3,447.30	5	3,356.64	4*d*?	3,275.93	4*c*	3,192.24	8*c*	3,109.34	2
3,445.93	4	3,356.03	3	3,275.68	7	3,189.70	4*d*?	3,107.81	3
3,445.51	3	3,355.59	3	3,274.93	10*c*	3,189.09	2	3,107.22	5
3,445.10	4	3,355.32	2	3,274.47	3	3,188.47	3	3,105.15	2
3,444.69	4	3,353.91	1	3,273.14	4	3,184.56	7	3,104.43	4
3,444.08	4	3,351.86	3*b*	3,272.62	2	3,182.57	6	3,104.18	2
3,441.56	2	3,351.51	6	3,271.19	2*b*	3,181.70	7*d*?	3,103.26	8
3,440.25	5	3,350.98	5	3,269.16	5	3,180.95	10*d*?	3,101.73	4
3,437.37	2	3,347.04	2	3,267.56	2*b*	3,179.54	4	3,101.43	2
3,437.08	2	3,345.08	3	3,266.87	3*c*	3,178.23	6*c*	3,096.11	3
3,436.01	7*c*	3,344.39	2*b*	3,265.34	2	3,177.93	4	3,095.40	7
3,434.50	5	3,343.44	4	3,264.10	3	3,176.30	7	3,093.88	6
3,430.92	8	3,339.91	7	3,263.77	4	3,174.38	2	3,093.00	4
3,429.33	2*n*	3,339.52	2	3,263.02	2	3,173.58	8	3,092.46	6
3,426.74	4	3,338.50	5	3,260.20	6	3,173.46	5	3,092.07	4
3,426.19	3	3,337.80	6	3,259.89	5	3,172.87	6*b*	3,089.92	2
3,424.44	5	3,337.50	3*b*	3,259.64	4	3,172.25	2	3,087.52	5
3,423.03	1	3,336.36	2	3,258.24	3*d*?	3,170.98	1	3,086.65	1
3,421.81	2	3,334.75	3	3,257.84	2	3,170.30	8*c*	3,085.55	6
3,421.21	2	3,333.09	3	3,256.78	4	3,168.19	3	3,084.53	3
3,419.74	5	3,332.81	4	3,255.69	2	3,167.53	5	3,082.46	5
3,419.53	4	3,332.41	5	3,253.81	2	3,166.38	4	3,081.85	10
3,418.32	3	3,331.48	2*b*	3,253.34	2	3,163.82	5	3,079.96	10
3,417.03	4	3,331.02	10*c*	3,251.92	3	3,163.55	4	3,079.30	5
3,415.88	4	3,329.55	3	3,250.36	5	3,163.13	5	3,078.24	8
3,415.28	4	3,328.93	3	3,250.03	2	3,162.73	5	3,077.24	15*d*?
3,414.14	10	3,328.29	3*d*?	3,248.53	6	3,161.85	2	3,076.54	4
3,413.64	3	3,325.74	4	3,246.90	3	3,161.43	3	3,076.39	7
3,412.92	5	3,324.86	2	3,245.29	4	3,160.81	1	3,076.09	3
3,411.71	4	3,319.47	4	3,243.38	3	3,159.04	5	3,075.31	6
3,410.77	2*b*	3,318.87	12*c*	3,242.84	8	3,157.96	4	3,073.39	7
3,406.96	8	3,318.55	5	3,242.57	3	3,155.51	4	3,072.34	7*b*
3,406.64	8	3,317.93	10*c*	3,242.05	8	3,154.71	2	3,072.08	2

TABLE 1.—*Wave lengths in the first spectrum of tantalum,* Ta I—Continued

λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes
3,070.54	5	2,985.05	2	2,915.49	25	2,850.97	25	2,789.33	3
3,069.21	20c	2,984.35	10	2,915.33	20	2,850.48	20	2,788.31	12
3,066.76	4	2,983.99	2	2,914.94	8	2,849.82	18	2,787.69	50
3,063.87	4	2,981.96	5	2,914.12	20	2,849.53	3	2,787.03	4
3,063.56	18r	2,981.18	7	2,913.32	7	2,848.52	12	2,783.69	10
3,061.98	2	2,980.76	7	2,907.77	5	2,848.03	15	2,782.76	3
3.061.81	4	2,980.32	2	2,906.48	2	2,847.28	6	2,781.79	15
3,060.27	15	2,979.57	2	2,906.17	2	2,846.75	12	2,781.37	25
3,058.65	15d?	2,978.74	20	2,905.73	10	2,845.82	8	2,780.64	2
3,057.12	5	2,977.73	4b	2,904.42	8	2,845.46	3	2,780.20	10
3,054.80	5	2,977.55	6	2,904.07	15	2,845.34	20	2,779.72	20+Cb?
3,051.91	6	2,976.76	10	2,902.61	8	2,844.76	10r	2,779.34	4
3,051.21	2	2,976.12	8	2,902.05	25	2,844.23	12r	2,779.11	35
3,050.98	3	2,975.54	20	2,901.64	3	2,842.80	15	2,775.90	20r
3,050.11	8	2,971.96	7	2,901.04	10	2,842.34	3	2,774.88	10
3,049.56	18	2,969.88	10	2,900.34	20r	2,839.76	7	2,772.59	4
3,048.87	12	2,969.47	20	2,899.02	10	2,837.93	12	2,770.76	10
3,048.31	5	2,967.84	2	2,898.41	10	2,836.61	12	2,768.90	4
3,045.95	15c	2,967.41	2	2,896.41	15W?	2,836.25	5	2,768.31	5
3,043.94	20	2,965.54	20r	2,895.08	12	2,834.41	15b	2,766.88	3
3,041.53	2	2,964.80	3	2,894.15	12	2,833.63	20	2,766.13	6
3,040.98	8	2,963.91	10	2,893.79	5	2,830.02	4	2,765.27	3
3,038.91	3	2,963.32	35	2,893.20	2	2,827.14	15b	2,764.77	6
3,036.28	6	2,963.06	6	2,892.87	2	2,826.42	10	2,764.27	4
3,035.82	4	2,962.09	2	2,892.25	2	2,826.19	12	2,761.52	5
3,034.98	2	2,961.39	3	2,892.00	10	2,825.05	4	2,761.16	2
3,033.40	3	2,958.13	4	2,891.84	30	2,824.81	8	2,760.69	3
3,030.28	8	2,957.58	12	2,891.02	15	2,824.05	3	2,758.31	20r
3,029.53	7	2,956.06	2	2,890.53	2	2,822.37	2	2,757.98	2
3,028.78	10	2,953.55	20	2,890.06	3	2,821.98	15	2,757.12	4
3,027.48	20c	2,951.92	30	2,889.37	15	2,821.17	6	2,752.29	10
3,025.17	10	2,948.51	3	2,888.13	2	2,819.38	8	2,751.04	4
3,024.28	5	2,947.81	10	2,886.63	7	2,818.74	5	2,750.55	4
3,022.77	4	2,947.39	3	2,885.71	2	2,817.50	10	2,748.77	20
3,022.28	7	2,947.18	2	2,884.96	3	2,816.16	2	2,747.84	7
3,021.55	2	2,946.91	25	2,883.88	7	2,815.79	2	2,747.25	12
3,019.66	10	2,946.27	5	2,882.33	15	2,815.11	10	2,746.68	8
3,019.09	8	2,943.77	8	2,881.21	6	2,814.80	10	2,745.56	4
3,016.36	10	2,942.13	20	2,880.00	20	2,810.91	25	2,743.58	10
3,012.84	2	2,940.21	25	2,879.73	10	2,810.06	2	2,742.91	8
3,011.88	15	2,940.02	20b	2,878.94	5	2,808.07	4	2,741.37	8
3,011.11	20	2,939.29	15	2,878.19	8	2,806.59	25	2,741.16	12
3,007.53	5	2,938.57	2	2,876.13	20b	2,806.29	20	2,740.18	8
3,006.54	8	2,938.44	10	2,874.93	5	2,805.08	7	2,737.09	4
3,005.04	4	2,937.49	2	2,874.75	2	2,804.75	10	2,736.24	20
3,004.92	12	2,937.30	2	2,874.51	6	2,804.02	7	2,734.52	5
3,004.14	6	2,935.95	8	2,874.14	12	2,802.71	20	2,733.68	3
3,001.53	10	2,935.58	4	2,873.56	15	2,802.50	5	2,732.91	10
2,997.02	4	2,935.15	4	2,873.34	15	2,802.06	30	2,732.05	12
2,996.86	4	2,934.85	10	2,871.40	25	2,800.82	2	2,730.32	3
2,996.00	3	2,934.50	2	2,869.52	5	2,800.56	15	2,729.50	2
2,993.60	4	2,933.54	30	2,869.20	2	2,800.33	2	2,729.27	3
2,993.13	8	2,932.67	25b	2,868.62	25	2,799.39	4	2,728.32	2
2,992.38	5	2,930.99	12	2,866.67	5	2,798.90	2	2,727.77	15
2,991.22	10	2,926.46	10	2,866.12	15	2,798.40	15r	2,726.32	8
2,990.73	4	2,925.65	10	2,865.09	2	2,796.55	15	2,725.07	6
2,989.88	3	2,925.21	30b	2,864.72	2	2,796.33	25	2,724.34	12
2,989.48	20	2,924.78	8	2,864.48	15	2,793.28	2	2,723.86	15
2,989.04	7	2,923.52	3	2,864.26	6	2,792.66	10b	2,723.26	8
2,988.56	15	2,922.41	4	2,862.36	4	2,791.67	20	2,722.89	2
2,987.16	4	2,920.30	5	2,861.98	20	2,791.16	3	2,722.32	5
2,986.40	6	2,917.11	8b	2,861.76	3	2,790.72	25	2,721.83	10
2,986.17	2	2,916.82	7	2,857.29	15	2,790.46	10	2,720.74	12
2,985.93	2d?	2,916.32	4	2,854.16	4	2,789.77	20	2,718.37	15
2,985.69	3	2,916.04	2	2,852.94	10	2,789.53	2	2,717.18	15

TABLE 1.—*Wave lengths in the first spectrum of tantalum,* Ta I—Continued

λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes	λ_{air}A	Intensity and notes
2,715.87	3	2,660.04	2	2,601.30	3	2,550.78	5	2,471.38	5
2,714.66	18r	2,659.66	12	2,601.05	15	2,550.57	4	2,471.24	3
2,711.92	2	2,657.69	4	2,600.14	10	2,550.46	5	2,469.76	4
2,710.12	20r	2,657.41	2	2,599.40	15+Fe?	2,549.39	10	2,468.07	4
2,708.35	6	2,657.30	10	2,599.10	2	2,547.23	2	2,465.38	2
2,708.14	5	2,656.61	30r	2,598.75	10	2,546.81	10	2,465.27	7
2,707.83	8	2,656.35	3	2,597.50	5	2,544.82	5	2,461.25	3
2,707.65	3	2,656.06	8	2,596.60	5	2,544.27	5	2,460.56	6
2,707.51	2	2,655.68	10	2,596.12	10	2,543.29	1	2,459.58	5
2,706.91	7	2,654.00	10	2,595.26	15r	2,542.23	5	2,458.69	5
2,706.68	12	2,653.27	50r	2,594.73	2	2,541.95	6	2,454.48	7
2,706.14	4	2,652.32	12	2,594.55	2	2,541.43	4	2,454.22	7
2,705.77	2	2,651.49	4	2,593.67	18	2,539.99	2	2,453.25	2
2,704.30	15	2,650.28	18	2,593.09	15	2,539.71	4	2,450.92	3
2,703.53	6	2,650.02	15	2,592.43	8	2,536.66	2	2,449.27	1
2,703.05	12	2,649.76	1	2,592.20	5	2,536.20	5	2,449.10	1
2,702.21	8r	2,648.71	3	2,590.94	10	2,535.97	8	2,447.94	2
2,701.60	10	2,648.23	1	2,590.49	3	2,535.60	8	2,443.93	5
2,700.68	10	2,647.47	30r	2,589.27	2	2,534.98	10	2,442.39	8
2,700.58	5	2,646.36	20r	2,589.14	2	2,534.48	8b	2,440.95	3
2,700.30	2	2,646.21	25	2,588.54	8	2,534.17	2	2,439.90	5
2,700.15	3	2,643.88	15	2,587.25	7b	2,533.01	10	2,437.06	6
2,698.29	20	2,643.24	7	2,585.62	10	2,531.51	4	2,434.72	3
2,696.80	15	2,642.24	10	2,584.90	3	2,531.29	10	2,433.78	1
2,694.75	12	2,641.92	1	2,584.69	10	2,530.97	3	2,433.15	4
2,693.93	3	2,641.06	3	2,582.24	3	2,530.87	2	2,432.21	2
2,693.50	10	2,640.92	4	2,581.19	2	2,528.96	5	2,431.65	7
2,693.34	15	2,638.27	5	2,580.84	2	2,526.66	10	2,431.41	2
2,692.39	18	2,636.90	30r	2,580.15	12	2,526.34	10	2,430.07	2
2,691.31	18r	2,636.67	25r	2,579.62	12	2,525.80	3	2,429.34	5
2,690.54	10	2,636.36	8	2,578.74	4	2,525.31	5	2,428.98	4
2,690.25	2	2,635.93	8	2,578.39	4	2,522.32	1	2,427.63	18
2,689.53	6	2,634.71	2	2,577.97	4	2,520.75	2	2,426.58	4
2,687.16	4	2,634.11	4	2,577.78	10r	2,520.31	5	2,422.81	4
2,686.95	2	2,629.98	6	2,575.47	15r	2,519.78	12	2,422.08	4
2,686.29	15	2,628.49	2	2,574.38	15	2,518.77	3	2,421.03	5
2,685.46	3	2,627.43	5	2,573.80	15	2,516.70	4	2,419.72	4
2,684.27	18r	2,627.06	5	2,573.54	18	2,515.15	5	2,417.69	5
2,681.88	12	2,626.07	3	2,572.10	3	2,512.64	12	2,416.56	2
2,681.64	4	2,625.80	4	2,571.19	4	2,512.03	6	2,414.32	4
2,677.87	5	2,625.46	8	2,569.79	2	2,511.01	4	2,412.67	4
2,677.66	2	2,624.12	8	2,567.48	4	2,509.18	6	2,407.56	6
2,677.46	2	2,623.16	2	2,567.34	4	2,507.45	15	2,406.55	10
2,677.16	5	2,622.95	2	2,566.74	3	2,505.90	1	2,404.22	5
2,675.54	3	2,620.19	10	2,566.33	12	2,504.68	4b	2,403.98	5
2,674.48	10	2,617.63	10	2,565.78	5	2,504.45	20	2,401.71	6
2,673.58	10	2,616.48	5	2,565.41	4	2,501.51	2	2,399.16	3
2,673.29	6	2,615.66	12	2,565.21	4	2,500.74	2	2,398.98	3
2,672.34	6	2,615.48	10	2,563.87	5	2,498.76	4	2,398.25	4
2,671.93	10	2,615.26	10	2,563.71	10	2,498.59	2	2,397.85	4
2,671.63	12	2,614.16	2	2,563.34	8	2,496.96	3	2,396.31	8
2,671.28	2	2,612.38	2	2,562.76	2	2,496.65	5	2,391.13	5
2,671.01	5	2,611.48	6	2,562.40	3	2,494.90	2	2,390.86	2
2,669.07	3	2,611.36	12	2,562.10	10	2,492.75	2	2,387.17	2
2,668.62	20	2,610.28	2	2,561.95	2	2,491.58	3		
								2,385.74	6
2,668.06	15	2,610.14	10	2,560.68	15	2,488.39	3	2,385.34	4
2,667.76	5	2,609.00	12	2,559.43	25	2,488.20	3	2,380.18	3
2,667.15	6	2,608.63	15r	2,558.95	2	2,486.70	8+Fe?	2,380.00	5
2,665.94	10	2,608.22	8	2,558.59	4	2,484.96	10		
2,663.42	2	2,606.56	3	2,556.93	3	2,478.83	2	2,378.52	2
								2,375.86	5
2,662.61	3	2,605.82	4	2,555.07	10	2,478.22	8	2,371.85	2
2,662.10	12	2,605.33	10	2,552.32	2	2,476.33	2	2,368.46	2
2,661.88	18	2,603.83	10	2,551.35	8	2,474.62	10		
2,661.33	30r	2,602.38	12	2,551.20	8	2,472.62	1		
2,660.23	3	2,601.98	3	2,551.06	12	2,472.14	8		

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